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ABSTRACT

Presented is the study of modern and classical concepts of the atom; the structure of the atom as a mass-energy relationship; practical uses of radioactivity; isotopes; and the strange particles. Performance objectives (16) are included as well as a detailed course outline. Experiments, demonstrations, projects and reports to enhance student learning experiences are suggested. To enhance creative thinking, a list of innovative activities has been compiled and presented. Available films, film loops and transparencies are included in the course of instruction. Additional instructional aids include: (1) suggested discussion questions; (2) references; (3) laboratory guides; and (4) a master sheet (coordinating objectives with suggested text chapters, laboratory exercises, projects, reports, etc.). (Author/EB)

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AUTHORIZED COURSE OF INSTRUCTION FOR THE QUINMESTER PROGRAM

ATOMIC PHYSICS

5318.42

SCIENCE

(Experimental)

DADE COUNTY PUBLIC SCHOOLS

DIVISION OF INSTRUCTION • 1971

SE 017 119

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(Experimental)

Written by Ralph E. Petit
for the
DIVISION OF INSTRUCTION
Dade County Public Schools
Miami, Florida
1972

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ATOMIC PHYSICS

COURSE DESCRIPTION

Study of the modern and classical concepts of the atom; the structure of the atom as a mass-energy relationship; practical uses of radioactivity; isotopes; and the strange particles.

ENROLLMENT GUIDELINES

1. Successful completion of Algebra I, Plane Geometry, and Algebra II is strongly recommended as an indicator of success in Atomic Physics.

2. Chemistry, Dynamics I, Kinematics, Electricity and Magnestism, and Light Theory are prerequisite to Atomic Physics.

SUGGESTED TEXT BOOK

1. Wehr, Russell and Richards, James. Physics of the Atom. Reading, Massachusetts: Addison-Wesley Publishing Company, 1967.

STATE ADOPTED TEXT

2. Rutherford, F. James, et al. The Project Physics Course Text. New York: Holt, Rinehart and Winston, Inc., 1970.

PERFORMANCE OBJECTIVES

1. Through illustrations and class discussions, the student will recognize the physical evidence for the atomic view of matter.

2. Given laboratory opportunity, the student will measure the ratio of charge to mass (q / m) of an electron.

3. Given reference material, the student will cite evidence for the existence of isotopes.

4. Given various conditions, the student will use Planck's constant and Einstein's photo electric equation to calculate the energy and momentum of photons.

5. Given appropriate data, the student will plot a graph of the energy levels from the Bohr model of an atom.

6. Given various conditions of mass and velocity, the student will become proficient in the process of problem solving involving the relativity mass-energy equivalence.

7. Given various conditions of frequencies and wave lengths, the student will become proficient in the process of problem solving involving the energy levels, intensity, absorption, and scattering of X-rays.

8. Given laboratory opportunity, the student will measure the absorption effect of certain materials on beta radiation.

9. Given laboratory opportunity, the student will measure the half-life of a radioactive element.

10. Given appropriate data, the student will compare the three series of naturally radioactive elements.

11. Given various examples of radioactivity, the student will distinguish between natural and man-made fission.

12. Given selected illustrations, the student will compare the construction and uses of nuclear reactors.

13. The student will cite evidence for the existence of the strange particles.

14. The student will discuss critically the advantages and disadvantages of nuclear reactions.

PERFORMANCE OBJECTIVES (Continued)

Optional

15. Given appropriate materials, the student will construct a cloud chamber to observe tracks of radioactive particles.

16. Given background information, the student will construct a model of a particle accelerator.

COURSE OUTLINE

I. Physical Evidence For The Atomic View Of Matter

A. Kinetic theory of gases

B. Maxwell's speed distribution law

C. Collision probability and mean free path

D. Perrin's atomic view of matter

II. The Atomic View Of Electrcity

A. Thompson's measurement of q/m

B. Positive rays

C. Isotopes

D. Mass spectroscopy

III. The Atomic View Of Radiation

A. Thermal radiation

B. Emission and absorption of radiation

C. Wein and Rayleigh-Jeans law

D. Planck's law

IV. Atomic Models

A. The Rutherford nuclear aton

B. The Bohr model

COURSE OUTLINE (Continued)

V. Relativity

A. Relativity mass transformation

B. Relativity mass - energy equivalence

C. Pair production

VI. X-rays

A. Production and nature of x-rays

B. Energy levels

C. Intensity measurements

D. Absorption coefficients

E. Compton scattering

VII. Natural Radioactivity

A. Discovery

B. The radiations

C. Radiation detectors

1. Geiger-Mueller counters

2. Cloud chambers

3. Bubble chambers

D. Energies of radiation

E. Radioactive series

1. The uranium series

2. The actinium series

3. The thorium series

COURSE OUTLINE (Continued)

F. Radioactive growth and decay

G. Secondary radiations

H. Radiation hazards

I. Radium radiations

J. Units of radiation

VIII. Nuclear Reaction and Artificial Radioactivity

A. Protons from nitrogen

B. Discovery of the neutron

C. Particle accelerators

1. Van de Graff electrostatic generator

2. Cyclotron

3. Bevatron

4. Cosmotron

D. The Cockcroft-Walton experiment

E. Nuclear mass - energy equations

F. Artificial radioactivity

G. Nuclear binding energy

H. Mossbauer effect

I. Modes of nuclide decay

IX. Nuclear Energy

A. Chain reactions

B. Neutron cross sections

C. Moderators

D. Reactors

COURSE OUTLINE (Continued)

1. Converter reactors
2. Research reactors
3. Power reactors
4. Boiling water reactors

E. Fusion

1. Natural
2. Man-made

X. High - Energy Physics

A. Cosmic rays

B. Mu-mesons

C. Pi-mesons

D. The strange particles

EXPERIMENTS

Holton, Gerald, et al. The Project Physics Course Handbook. New York: Holt, Rinehart and Winston, Inc., 1970.

1. The Charge-to-Mass Ratio of an Electron (Ex. 41, p. 289)
2. The Photoelectric Effect (Ex. 43, p. 295)
3. Random Events (Ex. 45, p. 316)
4. Range of Alpha and Beta Particles (Ex. 46, p. 321)
5. Half-Life I (Ex. 47, p. 324)
6. Half-Life II (Ex. 48, p. 328)
7. Radioactive Tracers (Ex. 49, p. 330)

Williams, John E., et al. Laboratory Experiments in Physics. New York: Holt, Rinehart and Winston, Inc., 1968.

8. Radioactivity (Ex. 18, p. 145)
9. Half-Life (Ex. 19, p. 149)

EXPERIMENTS (Continued)

Physical Science Study Committee. Physics Laboratory Guide. Atlanta: D. C. Heath and Company, 1965.

10. Simulated Nuclear Collisions (Ex. III - 10, p. 53)
11. Randomness in Radioactive Decay (Ex. IV - 14, p. 83)
12. The Spectrum of Hydrogen and Planck's constant (Ex. IV - 15, p. 84)

DEMONSTRATIONS

See Additional Innovative Activities.

PROJECTS

1. Design and construct a Wilson cloud chamber.
2. Design and construct a diffusion cloud chamber.
3. Design and construct a spintharioscope for viewing scintillations.
4. Design and construct a model of a nuclear reactor.
5. Using a vacuum tube or transistor type amplifier, design and construct a geiger counter.
6. Design and construct a small Van de Graff electrostatic generator. (Note. A small phonograph motor can be used to drive the belt.)
7. Make a model of a cyclotron.
8. Make a model of a betatron.
9. Make photographs of the tracks made in the diffusion cloud chamber and calculate the energy of the emitted particles.

REPORTS

1. Nuclear Reactors
2. Power Reactors in Small Packages
3. Nuclear Power and Merchant Shipping
4. Atomic Fuel
5. Direct Conversion of Energy
6. Power from Radioisotopes
7. Atomic Power Safety
8. Controlled Nuclear Fusion
9. Food Preservation by Irradiation
10. Fallout from Nuclear Tests
11. Radioisotopes in Industry
12. Nuclear Energy for Desalting
13. Effects of Radiation on Mammals
14. Properties of Heavy Water
15. Purification of Contaminated Water
16. Radiochromatography
17. Discovery of Isotopes
18. Medical Uses of Radioisotopes
19. Report on the Atomic Research of the Following Scientists:

    A. Max Planck
    B. Albert Einstein
    C. Niels Bohr
    D. Arthur H. Compton
    E. Louis de Broglie
    F. G. I. Taylor
    G. Ernest Rutherford
    H. Henri Becquerel
    I. J. J. Thompson
    J. Pierre and Marie Curie
    K. Enrico Fermi

REPORTS (Continued)

20. Carbon Dating
21. Radiation on Plants
22. Breeder Reactors
23. Insect Control By Irradiation
24. The Discovery of Neutrons
25. The Functions of the Atomic Energy Commission
26. The Use of Nuclear Power in Submarines
27. Thermal Effect of Steam - Electric Generating Plants
28. Genetic Damage by Radiation
29. Van Allen Radiation Belts
30. Nobel Prize Winners in Atomic Physics

INNOVATIVE ACTIVITIES

1. Using magnets, try to demonstrate the Rutherford scattering of alpha particles.
2. Set-up apparatus to show the deflection of beta particles by a magnetic field.
3. Using turntable oscillators, draw pictures that resemble the de Broglie waves.
4. Charge an electroscope. Compare its discharge rate with different samples of radioactive materials.
5. Use mousetraps to set-up a demonstration of a chain reaction.
6. Measure the absorption of radioactive phosphates by a plant.
7. Measure the absorption of various radioactive minerals by a plant.

INNOVATIVE ACTIVITIES (Continued)

8. Determine the distribution of radioisotopes in the stems, leaves and roots of a plant.

9. Measure the absorption of radioisotopes in fish.

10. Study radiation sickness using frogs. (Local hospitals may be used for the irradiations)

11. Determine the amount of fallout in milk or rain water.

12. Radiography? Make radiograms of metal screws imbedded in wood.

FIELD TRIPS

1. Florida Power and Light
   Turkey Point Plant

2. Radiological laboratories at various hospitals

3. Physics Department
   University of Miami

4. State Agriculture Department

5. Applied Research Laboratory of Florida
   (See yellow pages of telephone directory)

6. Visit laboratories that specialize in testing of various things
   (See yellow pages of telephone directory under Laboratories - Testing)

7. Physics Department
   Miami-Dade Junior College

FILMS AVAILABLE FROM DADE COUNTY AUDIOVISUAL CENTER

1. Atomic Energy (E B E C)
AV# 1-01940, 10', B/W

2. Atomic Power (McGraw-Hill)
AV# 1-10918, 19', B/W

3. Atomic Research: Areas and Development (Coronet)
AV# 1-10788, 13', B/W

4. Carbon Fourteen (E B E C)
AV# 1-01926, 12', B/W

5. Fundamentals of Radiac Instruments (U W)
AV# 1-31326, 25', B/W

6. Nuclear Radiation: Detectors (Cenco)
AV# 1-10798, 15', C

7. Nuclear Radiation in Outer Space (Cenco)
AV# 1-11423, 17', C

8. Our Friend, The Atom (Part 1, Walt Disney)
AV# 1-30333, 50', C

9. Our Friend, The Atom (Part 2, Walt Disney)
AV# 1-30335, 50', C

10. Principles of Nuclear Fission (McGraw-Hill)
AV# 1-10797, 20', C

11. Rutherford, Atom, The (0416, M L A)
AV# 1-40022, 25', B/W

12. Strange Case of the Cosmic Rays, The (Part 1, So. Bell)
AV# 1-30243, 30', C

13. Strange Case of the Cosmic Rays, The (Part 2, So. Bell)
AV# 1-30246, 30', C

14. Unlocking the Atom (U W)
AV# 1-10787, 19', B/W

15. Atom Smashers (E B E C)
AV# 1-01922, 12', B/W

FILMS AVAILABLE FROM DADE COUNTY AUDIOVISUAL CENTER (Continued)

16. Frank-Hertz Experiment, The (0421, M L A)
AV# 1-30337, 25', B/W

17. Photo-Electric Effect (0417, M L A)
AV# 1-30317, 28', C

18. Random Events (0116, M L A)
AV# 1-30249, 31', B/W

United States Atomic Energy Commission

Approximately 150 films are available for free loan to schools. For free catalog of these films and information for ordering, write:

Film Librarian
U. S. Atomic Energy Commission
P. O. Box A
Aiken, South Carolina 29801
Telephone: 301-973-4239

TRANSPARENCIES

Dade County Audiovisual Center

1. Atomic Structure (Ideal)
AV# 2-00085, B/W

The Project Physics Course Materials. New York: Holt, Rinehart and Winston, Inc., 1970.

2. Photoelectric Experiment.
3. Photoelectric Equation.
4. Separation of Alpha, Beta, and Gamma Rays.
5. Rutherford's Alpha-particle "Mousetrap".
6. Radioactive Disintegration Series.
7. Radioactivity Displacement Rules.
8. Mass Spectrometer
9. Chart of Nuclides
10. Nuclear Equations
11. Binding Energy Curves

FILM LOOPS

The Project Physics Course Materials. New York: Holt, Rinehart and Winston, Inc., 1970. Super 8.

1. Rutherford Scattering (#48)
2. Thompson Model of the Atom (#47)
3. Collisions With an Unknown Object (#49)

RELATED SOLVED PROBLEMS

1. Castka, Joseph F. and Leffer, Ralph W. Physics Problems. New York: Holt, Rinehart and Winston, Inc., 1961.
2. Dillon, Thomas J. and Smith, Malcolm K. Concepts in Physics, Teacher's Manual and Answer Key. Atlanta: Harcourt, Brace, Javanovich, 1970. (pp. 236-262)
3. Physical Science Study Committee. P.S.S.C. Physics Teacher's Resource Book and Guide. Boston: D. C. Heath and Company, 1965. (Part 4)
4. Schaum, Daniel. Theory of Problems of College Physics, 6th Edition. New York: Schaum Publishing Company, 1961. Reprint 1966.
5. Williams, John E., et al. Modern Physics Teacher's Edition. New York: Holt, Rinehart and Winston, Inc., 1968.

SUGGESTED DISCUSSION QUESTIONS

1. How was radioactivity discovered?
2. Name the naturally radioactive elements.
3. What are the effects of radioactive radiation?
4. What is an alpha particle?
5. What is a beta particle?
6. What is a gamma ray?

SUGGESTED DISCUSSION QUESTIONS (Continued)

7. What is a cosmic ray?

8. What is meant by the half-life of an element?

9. What is the unit of radiation and what does it mean?

10. In a nuclear equation, like ${}_{6}C^{14}$, what do the numbers represent?

11. What is the purpose of the moderator in a nuclear reactor?

12. What are radioisotopes?

13. What is critical mass?

14. What are the conditions for a chain reaction?

15. Why are neutrons used as bullets for bombarding nuclear rather than other particles?

16. Where does the energy come from in a nuclear reaction?

17. How did Rutherford obtain the alpha particles used in his scattering experiments?

18. Is there a relationship between the atomic number of an atom and the number of isotopes of that atom?

19. What is Mev? Bev?

20. How is U - 235 separated from U - 238?

21. How can atomic energy be used to produce electricity?

22. How can an atomic explosion be detected at other spots on the world thousands of miles away?

23. Where does the sun get its energy?

24. Which chemical elements have been discovered from nuclear research?

25. What is background radiation?

26. What is a "cutie pie"?

SUGGESTED DISCUSSION QUESTIONS (Continued)

27. What is fallout?

28. Distinguish between fission and fusion reactions.

29. What is a hot cell? A hot spot?

30. What is: (1) a nuclei; (2) a nucleon; (3) a nucleus; (4) nuclide?

31. What are strange particles?

REFERENCES

1. Cohen, Bernard L. The Heart of the Atom: The Structure of the Atomic Nucleus. New York: Doubleday and Company, Inc., 1967.

2. Gamon, George. The Atom and Its Nucleus. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1961.

3. Glasstone, Samuel. Sourcebook on Atomic Energy. Princeton, New Jersey: D. Van Nostrand Company, Inc., 1967.

4. Halliday, David and Resnick, Robert. Physics, Parts I and II. New York: John Wiley and Sons, Inc., 1967.

5. Jaworski, Irene D. and Joseph, Alexander. Atomic Energy. New York: Harcourt, Brace and World, Inc., 1961.

6. Lehrman, Robert L., and Swartz, Clifford. Foundations of Physics. New York: Holt, Rinehart and Winston, Inc., 1965.

7. Marantz, Samuel A. Physics. New York: Benziger Brothers, 1969.

8. Miller, Franklin, Jr. College Physics. Atlanta: Harcourt, Brace and World, Inc., 1967.

9. Miller, Franklin, Jr., et al. Concepts in Physics. Atlanta; Harcourt, Brace and World, 1969.

10. Physical Science Study Committee. Physics. Atlanta: D. C. Heath and Company, 1965.

11. Rossi, Bruno. Cosmic Rays. New York: McGraw-Hill Book Company, Inc., 1964.

REFERENCES (Continued)

12. Ruchlis, Hyman, and Lenon, Harvey B. Exploring Physics. New York: Harcourt, Brace and Company, 1952.

13. Rutherford, F. James, et al. The Project Physics Course Text. New York: Holt, Rinehart and Winston, Inc., 1970.

14. Schaum, Daniel. Theory and Problems of College Physics. New York: McGraw-Hill Book Company, 1961, Reprint 1967.

15. Shilling, Charles W. Atomic Energy Encyclopedia in the Life Sciences. Philadelphia, Pennsylvania: W. B. Saunders Company, 1964.

16. Waite, Harvey E., et al. Physics, An Experimental Science. Princeton: D. Van Nostrand Company, Inc., 1968.

17. Williams, John E., et al. Modern Physics. New York: Holt, Rinehart and Winston, Inc., 1968.

18. Woodbury, David O. Atoms for Peace. New York: Dodd, Mead and Company, 1965.

Note:

The U. S. Atomic Energy Commission publishes Understanding the Atom Series of Educational booklets for high school science students and their teachers. The series explains many aspects of nuclear science, technology, research, and history.

Librarians may obtain free complete sets of the booklets. Teachers may obtain free those categories of booklets most applicable to the course they teach.

Write to: USAEC - Technical Information
P. O. Box 62
Oak Ridge, Tennessee 37830

LABORATORY GUIDES

19. Holton, Gerald, et al. The Project Physics Course Handbook. New York: Holt, Rinehart and Winston, Inc., 1970

20. Physical Science Study Committee. Physics Laboratory Guide. Atlanta: D. C. Heath and Company, 1965.

21. Williams, John E., et al. Exercises and Laboratory Experiments in Physics. New York: Holt, Rinehart and Winston, Inc., 1968.

MASTER GRID--ATOMIC PHYSICS

Objectives	Texts	Labs	Projects	Reports	Field Trips	Transparencies	Films	Film Loops	Discussion Questions	Related Problems	Additional Activities	References
1	#1. ch. 1	3,10,11	3,5		3,7	1	8,9 U.S.A.E.C.			1-5	1	All
2	#1. ch. 2 #2. ch. 19	1			3,7		U.S.A.E.C.	2		1-5		All
3	#1. ch. 2 #2. ch. 22 23			17		8	U.S.A.E.C.		12,18		2	All
4	#1. ch. 3 #2. ch. 18 19	2,12		19a,19b		2,3	17 U.S.A.E.C.			1-5		All
5	#1. ch. 4 #2. ch. 18 19			19c,19d, 19g		11	11,16 U.S.A.E.C.	1	17	1-5	3	All
6	#1. ch. 5			5			U.S.A.E.C.		16	1-5		All
7	#1. ch. 6	8		19d,19e		11	U.S.A.E.C.			1-5	4	All
8	#1. ch. 6 #2. ch. 21	4			3,7	4	U.S.A.E.C.					All
9	#1. ch. 10 #2. ch. 21	5,6,9			3,7		18 U.S.A.E.C.		2,8			All
10	#1. ch. 10					6,7,9, 10	9,10 U.S.A.E.C.		2,10,30			All
11	#1. ch. 11 #2. ch. 23			4,8,14, 24	1	5	7,14,15 U.S.A.E.C.		9,13,14,30, 22,23,25,28		5	All
12	#1. ch. 12 #2. ch. 23 24		4	1,2,19j, 22	1		U.S.A.E.C.		11,13,14, 21,29			All
13	#1. ch. 13						12,13 U.S.A.E.C.		4,5,6,7			All
14		7		3,6,7,9, 10,11,12, 13,15,16, 18,21,23, 25,26,27, 28,29,30	1,2,4, 5,6		1,2,3,4,5 U.S.A.E.C.		3,9,27		6,7,8,9, 10,11,12	All
15	#2. ch. 24		1,2,9		3,7		U.S.A.E.C.	3	1,15,26			All
16	#2. ch. 23		6,7,8		3,7		15 U.S.A.E.C.	3	15,19,24			All